

## Ethnobotanical study of forage/fodder plant species in and around the semi-arid Awash National Park, Ethiopia

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**Abstract:** We undertook ethnobotanical study of forage/fodder plant species used by the Afar and Oromo (Kereyu and Ittu) Nations in and around the semi-arid Awash National Park (ANP), Ethiopia. The study aimed at investigating and documenting indigenous knowledge (IK) on forage/fodder plant species and threats to their survival. Ninety-six informants between 20 and 80 years old were selected using prior information. Data were collected using semi-structured interview, guided field walk, discussion and field observation. Preference ranking, Jaccard's coefficient of similarity and priority ranking were used for data analysis. One hundred twenty-six forage/fodder species of 90 genera and 43 families were collected in the study area. More than 88% of the species were reported with their vernacular names, where 68% were reported by the Afar Nation and 70% by the Oromo Nation. Family Poaceae was represented by 25 species (20%), followed by Fabaceae 18 (14%). Preference ranking for the most preferred forage grasses as perceived by key informants revealed that *Chrysopogon plumulosus* was the most important forage/fodder species. Overgrazing was the major threat in the study area, scoring 22%.

**Keywords:** Awash National Park, conservation, forage/fodder species, overgrazing

### Introduction

Various parts of shrubs and trees especially leaves, pods, seeds

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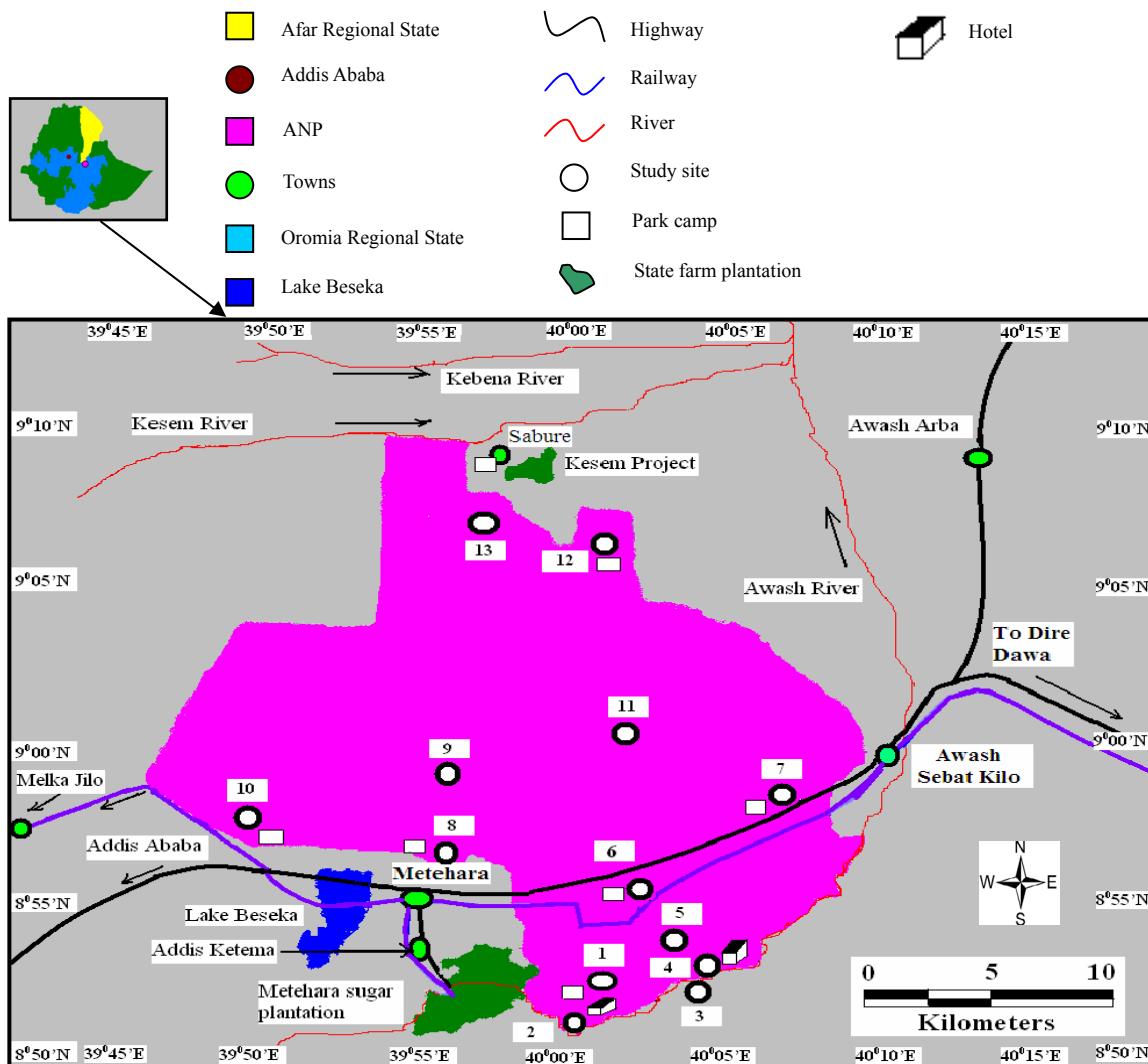
and edible twigs are used as supplementary feeds for animals (Ivory 1990). In dryland farming areas grasses account for 89% of livestock diets that consist of 11% shrubs and tree fodder (Nittis et al. 1990). Although grasses and legumes are the major components of diets in traditional animal feeds (Devendra 1990), in arid and semi-arid regions of the world, shrubs and tree fodders are important components of animal diets. This is because of spatial and seasonal shortage of pasture, increasing livestock numbers and shortage of grazing lands (Devendra 1990). Livestock diets vary by species, e.g.: goats and camels typically prefer shrubs and trees, whereas cattle and sheep prefer grasses. More than 40% of damage to young forest trees in protected areas has been attributed to overgrazing by livestock (BSE 2004). Overgrazing by large numbers of livestock is one of the major threats to the vegetation of Awash National Park (ANP) (Jacobs and Schloeder 1993; BSE 2004). We undertook an ethnobotanical study of forage/fodder species used by indigenous peoples of the Afar and the Oromo Nations in and around ANP. We recorded, compiled, and documented local indigenous knowledge (IK) to guide the proper utilization, management, and conservation of useful plants and the landscapes of ANP.

### Materials and methods

#### Study area

#### Geographical location

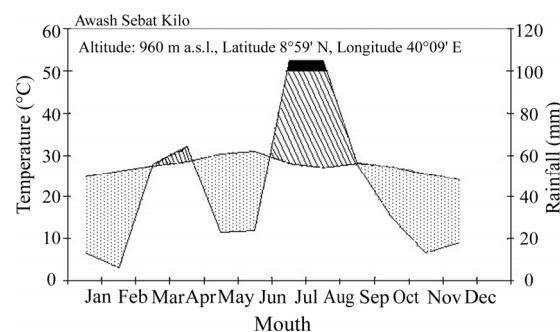
Our study was conducted in ANP, Ethiopia, 225 km from Addis Ababa at 8°50'–9°10' N and 39°45'–40°10' E (EMA 1992) (Fig. 1). The park covers approximately 756 km<sup>2</sup> and is bordered by the Sabober plain to the west, the Awash River to the south and southeast and Kesem River and Filwuha Hot Springs to the north (Jacobs and Schloeder 1993). ANP was established as a protected area in 1966 (BLI 2009; EWCA 2009) and legally gazetted in 1969 for the protection and conservation of wildlife resources and their natural habitats (Andeberhan 1982; IUCN/UNEP 1987; Jacobs and Schloeder 1993; Shibru 1995; BLI 2009).



**Fig. 1:** Study sites in Awash National Park (Ethiopia): 1. Gotu, 2. Awash River, 3. Awash Gorge, 4. Karreyu Lodge, 5. Ilala Sala plain, 6. Hamareti, 7. Geda, 8. Sogido, 9. Mt. Fentale, 10. Sabober, 11. Dunkuku (Kudu Valley), 12. Filwuha, and 13. Sabure (Awash Sebat Kilo is located in altitude: 960 m asl.,  $8^{\circ}59' N$  and  $40^{\circ}09' E$ )

#### Climate

ANP is characterized by semi-arid climate with the annual rainfall of 400–700 mm. The area is located within the Inter-Tropical Convergence Zone where there is high temporal and spatial variability in rainfall, humidity and temperature (Jacobs and Schloeder 1993). Rainfall is bimodal with two distinct seasons, *i.e.* the *short* rains between February and April and the *long* rains between July and September (Jacobs and Schloeder 1993; Almaz and Maresha 1999). The highest mean monthly rainfall of the study area during the most recent decade as recorded at Awash Sebat Kilo station was 120.8 mm recorded in July and the lowest mean monthly rainfall was 5.9 mm in February. Likewise, the highest average monthly temperature during the recent decade was 30.6°C in June and the lowest average monthly temperature was 24.2°C in December (Fig. 2).



**Fig. 2:** Climadiagram at Awash Sebat Kilo meteorological station, east of ANP (from 1999–2008), raw data are obtained from NMSA (2009).

### Geology, soil and hydrology

Jacobs and Schloeder (1993) reported that ANP is found in a zone of interface between two tectonic mega-structures, the African and Somali plates. These plates are pulling apart (rifting) and away from the Arabian plate. Thus ANP occurs in one of the most geologically active regions of the world. The phenomena of rifting and volcanism are continuous processes that are estimated to have continued for 25–30 million years in Ethiopia and for about 5 million years in ANP. Jacobs and Schloeder (1993) reported that ancient alluvial and colluvial soils, soils of volcanic origin, and recent alluvial soils are the major soil types of the study area. The major water sources in the study area include Awash River with major tributaries around ANP including the Kesem and Kebena Rivers, Lake Beseka and the Hot Springs at the northern tip of ANP.

### Vegetation and wildlife

Of the nine vegetation types of Ethiopia, the vegetation type of ANP is classified as *Acacia-Commiphora* woodland (Sebsebe and Friis 2009) in the Somali-Masai Regional Center of endemism (White 1983). ANP supports at least 81 species of mammals, 453 species of birds and 43 species of reptiles (Jacobs and Schloeder 1993). Various sources indicated that ANP is home to one critically endangered and endemic mammal, Swayne's Hartbeest (*Alcelaphus biselaphus swaynei*) and five vulnerable species (Lesser horseshoe bat, *Rhinolophus hiposiderose minimus*; Trident leaf-nosed bat, *Asellia patrizii*; Spot-necked otter, *Lutra maculicollis*; lion, *Panthera leo* and Soemmerring's gazelle, *Gazelle soemmerringi*).

### People and land use

Human activities around ANP include pastoralism, crop agriculture and harvesting natural resources (Jacobs and Schloeder 1993). Pastoralists living around ANP belong to the Afar and the Oromo Nations. The Afar pastoralists in the north and northeast of ANP represent the Afar Nation. The Afar Nation is situated in the Awash-Fentale Wereda (District) of the Afar Regional State (RS) (Region 2). Its administrative town is Awash Sebat Kilo. It has six Kebeles, namely Awash, Boloya, Doho, Dudub, Kebena and Sabure. Kebele, an Amharic term, is part of a Woreda and the smallest administrative division or structure in Ethiopia. Doho, Dubub and Sabure surround ANP. Based on the population census conducted by FDREPCC (2008) in Ethiopia, the total population of Awash-Fentale Wereda is about 29,775 of which 15,471 (51.9%) are males and 14,304 (48%) are females.

Kereyu and Ittu pastoralists occupy the western and southern parts of ANP, and belong to the Oromo Nation. The Oromo Nation occupies the Fentale Wereda of the Oromia RS (Region 4). The administrative town of Fentale Wereda is Metehara. A total of 18 Kebeles are in the Wereda. Of these, three Kebeles surround the Park, namely Benti, Fate Leidy and Gelcha. According to the population census reported by FDREPCC (2008) in Ethiopia, the total population of Fentale Wereda is about 82,225 of which 43,510 (52.9%) are males and 38,715 (47.1%) are females.

The primary economic activity of both Nations is livestock

production. Both Nations are transhumant pastoralists, i.e., pastoralists who maintain permanent settlements, but shift their livestock seasonally so as to utilize the resources (pasture and water) found far away from settlement areas. Both Nations enter in the Park during some periods to use the resources.

### Ethnobotanical data collection

After a reconnaissance survey during 15 to 30 August, 2008, 13 study sites were selected and established as data collection sites (Fig. 1). Ethnobotanical data were collected between September, 2008 and March, 2009 during three field trips to each study site, following the methods by Martin (1995), Cotton (1996) and Cunningham (2001). To quantify local IK of forage/fodder species in and around ANP, we sampled informants and key informants based on a checklist of questions (Appendix 1) using the Afar language (Af) and Oromo language (Or) with the help of translators. Our sampling methods included semi-structured interview, guided field walk, discussion and observation. Key informants were informants who had better knowledge of forage/fodder species than informants. Voucher specimens were collected, identified and kept at the National Herbarium, Addis Ababa University. Informants were selected from the Afar and/or the Oromo Nation based on the proximity of their Kebele to the Park. Informants were selected from four Kebeles of the Afar Nation (Awash, Doho, Dudub and Sabure Kabeles), and five Kebeles of the Oromo Nation (Benti, Fate Leidy, Gelcha, Ilala and Kobo Kabeles). Of these, a total of 96 informants (76 men and 20 women) between the ages of 20 and 80 were selected using prior information. Out of these informants, 36 key informants (32 men and 4 women) were selected. In each study site, 7 or 8 informants and/or key informants were selected. Basic information on forage/fodder species was recorded as related by informants. Recorded data included local forage plant names, plant part(s) eaten, species and numbers of foraging livestock managed by each informant, and any additional uses of forage plants.

### Ethnobotanical data analysis

Data were analyzed and summarized using simple preference ranking and direct matrix ranking, following Martin (1995) and Cotton (1996). Jaccard's Coefficient of Similarity (JCS) was calculated and the similarity in forage/fodder species composition between the Afar and the Oromo Nations was compared following Kent and Coker (1992). JCS was calculated for paired habitat types (A and B) as follows:

$$JCS = \frac{c}{c + b + a} \quad (1)$$

where,  $a$  is the number of species found only in habitat A,  $b$  is the number of species only in habitat B and  $c$  is the number of common species in habitat A and B.

Finally, JCS was multiplied by 100 to calculate the percentage similarity in species composition between the Afar and the

Oromo Nations, following Kent and Coker (1992).

## Results and discussion

### Diversity and distribution of forage/fodder species

Adequate pasture and the availability of forage/fodder resources are central economic concerns in the study area. We collected 126 forage/fodder species used and identified by local communities. These were distributed among 90 genera and 43 families (Appendix 1). Personal observation and discussion with informants indicated that pastoralists were familiar to forage/fodder species and able to identify the species with respect to their palatability to livestock. This result is in agreement with studies by Gemedo et al. (2005) of forage utilization by the Borana pastoralists. More than 88% of the forage/fodder species were reported with their vernacular names. Of all reported vernacular names, 68% were reported by the Afar Nation and 70% by the Oromo Nation. There were also cases where 2 or 3 vernacular names were reported for a single species.

Of these, 57 species were considered suitable as forage (grasses and herbs) and 69 were fodder species (trees and shrubs). Despite the higher proportion of fodder than forage species, pastoralists mostly depended on grasses rather than trees-shrubs for their livestock feed. Over 52% of the forage species were grasses. Fodder species were typically less available for livestock feed during dry season, which is a time of overall feed shortage. Of the total forage/fodder species encountered, Poaceae accounted for 25 species (20%), followed by Fabaceae 18 (14%), indicating that the study area was well suited for livestock grazing and/or browsing. Anteneh (2006) also reported that about 45% of the

forage species were Poaceae and Fabaceae.

The plant parts most often eaten by livestock were leaves of 54 plant species (43%), followed by above ground parts of 28 (22%) species, and leaves and fruits of 24 species (19%). All remaining plant parts accounted for 16% of livestock diets. Of all forage/fodder species, 39 species (31%) were considered most preferred by camels and goats, 29 species (23%) by all animals and 28 species (22%) by cattle. The remaining 30 plant species (24%) were used by cattle, goats, and camels. ANP was suitable for grazing by all types of livestock based on the occurrence of most commonly preferred forage/fodder species of livestock, viz. leaves and above ground parts.

Preference ranking of the seven most popular and widely used forage grasses based on their forage value revealed that *Chrysopogon plumulosus* ranked first, followed by *Bothriochloa radicans*. *Tetrapogon tenellus* was the least preferred forage grass in the study area (Table 1). Most of the informants explained that *Chrysopogon plumulosus* is one of the most important forage grasses and is preferred by all livestock in the area throughout the year. It is also drought resistant even during long dry seasons. BLI (2009) reported that *Chrysopogon plumulosus* is a highly palatable and important species for domestic and wild grazing animals in ANP. Selective grazing by livestock in many areas of ANP makes this species more scarce and sometimes replaced by unpalatable species. This is due to the fact that *Chrysopogon plumulosus* is sensitive to high intensity grazing by livestock (Almaz and Masresha 1999). Although *Bothriochloa radicans* has high protein value and is preferred by livestock, the preference of grazers for *B. radicans* is reduced by its unpleasant smell when grazed by livestock (Almaz and Masresha 1999).

**Table 1:** Preference ranking of seven most selected forage grasses based on their palatability to livestock as perceived by key informants in the study area

Forage grasses	Key informants														Total score	Rank	
	R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>	R <sub>4</sub>	R <sub>5</sub>	R <sub>6</sub>	R <sub>7</sub>	R <sub>8</sub>	R <sub>9</sub>	R <sub>10</sub>	R <sub>11</sub>	R <sub>12</sub>	R <sub>13</sub>	R <sub>14</sub>	R <sub>15</sub>		
<i>Bothriochloa radicans</i>	7	6	4	5	1	3	6	7	6	5	7	4	4	4	6	75	2 <sup>nd</sup>
<i>Chrysopogon plumulosus</i>	6	7	7	3	7	6	4	5	7	6	5	5	6	7	7	88	1 <sup>st</sup>
<i>Cenchrus ciliaris</i>	3	4	3	6	6	7	7	3	5	7	6	2	7	5	3	74	3 <sup>rd</sup>
<i>Panicum maximum</i>	5	5	6	4	2	5	5	6	3	4	4	3	5	6	4	67	4 <sup>th</sup>
<i>Sporobolus ioclados</i>	2	3	1	1	5	2	2	1	2	3	3	6	2	3	5	41	6 <sup>th</sup>
<i>Tetrapogon cenchriformis</i>	4	1	2	7	3	4	1	2	4	1	1	7	3	1	1	42	5 <sup>th</sup>
<i>Tetrapogon tenellus</i>	1	2	5	2	4	1	3	4	1	2	2	1	1	2	2	33	7 <sup>th</sup>

*Cenchrus ciliaris* and *Panicum maximum* are valuable forage grasses in the study area. However, *P. maximum* cannot withstand overgrazing, unlike *C. ciliaris* (Fröman and Persson 1974). Informants reported that *Tetrapogon cenchriformis* provides good livestock forage and it emerges soon after the beginning of short rains between February and April, a time of annual feed shortage. Fröman and Persson (1974) reported that *T. cenchriformis* is a highly palatable grass species that appears soon after the beginning of the rains to provide good grazing for livestock.

Informants reported that pastoralists mainly sustain their livestock on grazing lands where there is supplemental shrub/tree fodder, especially in the dry season and during prolonged

drought in the semi-arid ANP. *Acacia* species are the most widely used plant species in the area, especially during dry seasons and prolonged drought. Most of the time, the leaves, fruits and pods of *Acacia tortilis* are collected and fed to livestock or brought to other animals that are kept around homesteads. *A. tortilis* is one of the most widely used species by Borana pastoralists for livestock feed (Gemedo et al. 2006). Drought resistant forage/fodder plant species are very important resources for livestock production and productivity as well as for pastoralist livelihood. Some of the drought resistant shrub and tree fodders used for animal feed by the local communities include *Acacia*, *Ziziphus* and *Grewia* species, *Balanites aegyptiaca*, *Cadaba*

*farinosa*, *Ficus sycomorus*, *Olea europaea* subsp. *cuspidata*, *Prosopis juliflora*, and *Salvadora persica*.

#### Indigenous categories of forage grasses

During discussion sessions informants identified 19 of 25 forage grasses and ranked them based on their palatability to livestock into three major categories, viz. highly desirable, intermediate, or least desirable (Table 2). Highly desirable and valuable forage grasses (e.g., *Chrysopogon plumulosus*) were frequently and continuously preferred by pastoralists for livestock grazing. As a result, they are less frequent especially in overgrazed and degraded areas as compared to the least desirable forage grasses. A similar pattern was documented by Gemedo (2004) and Gemedo et al. (2006) in the Borana rangeland. The grass species of intermediate palatability, e.g. *Chrysopogon aucheri*, are not all attributable to livestock. Thus, these species are usually grazed during shortage of pasture and dry season when the most desirable grass species are scarce. This result also partly reported by Robertson (1970) for *Beisa oryx* grazing habit in the ANP. Due to this reason, *Chrysopogon aucheri* is the most dominant and frequent grass species under overgrazed condition in the open grasslands (Sogido, Saboer) of the study area. Other grass species of intermediate palatability such as *Aristida adscensionis* and *Hyparrhenia* species are grazed during early growth stages but are unpalatable during later maturity stages when they grow coarse and stemmy (Fröman and Persson 1974).

The least palatable grass species such as *Pennisetum setaceum* and *Pennisetum menzianum* are of a genus categorized by Fröman and Persson (1974) and Gemedo et al. (2006) as unpalatable. Nevertheless, they are grazed during prolonged drought and dry seasons, when there is a severe shortage of pasture. *P. setaceum* was the least preferred by all livestock and had no grazing value as perceived by key informants in our study area. This is because the grass is too hard to graze due to its strong texture and it cuts (bruises) the tongues of livestock. For this reason the grass is called ARABA MURI (Or), which means tongue cutter.

**Table 2:** Indigenous peoples' perceptions of three major categories of forage grasses in the study area

Major categories of forage grasses		
Highly desirable	Intermediate	Least desirable (Undesirable)
<i>Chrysopogon plumulosus</i>	<i>Chrysopogon aucheri</i>	<i>Pennisetum setaceum</i>
<i>Bothriochloa radicans</i>	<i>Aristida adscensionis</i>	<i>Pennisetum menzianum</i>
<i>Cenchrus ciliaris</i>	<i>Hyparrhenia anamesa</i>	<i>Cymbopogon pospischilii</i>
<i>Panicum maximum</i>	<i>Hyparrhenia diplandra</i>	<i>Sporobolus pyramidalis</i>
<i>Tetrapogon cenchriiformis</i>	<i>Hyparrhenia hirta</i>	<i>Sporobolus spicatus</i>
<i>Sporobolus ioclados</i>	<i>Hyparrhenia rufa</i>	<i>Sorghum arundinaceum</i>
<i>Tetrapogon tenellus</i>		

#### Forage/fodder species uses

Some of the recorded forage/fodder species in the study area are

also used in medicines, foods, fuel wood (charcoal and firewood), material culture and miscellaneous uses. Of the total recorded forage/fodder species, about 16% had 4 distinct uses, 7% had 5 uses and 5% had 6 uses for local people (Appendix 1).

#### Variation of indigenous knowledge between the Afar and the Oromo Nations

Twenty-two forage/fodder species were reported only by the Afar Nation, 15 species only by the Oromo Nation, and 89 species were common to both Nations. The Afar Nation reported more forage/fodder species than did the Oromo Nation, possibly because the Afar Nation was mainly engaged in livestock production and hence more familiar with forage/fodder species. The Oromo Nation was better characterized as agro-pastoralists trending towards sedentary agriculture. Jaccard's coefficient of similarity (71%) for the species indicated that the two groups, situated in close geographical proximity, shared experience and knowledge. Thus, they commonly utilized the same species.

#### Threats to forage/fodder species and associated indigenous knowledge

Because the local peoples typically have intimate relationships with their natural environment, they are familiar with the threats to forage/fodder species. During both group and individual discussions, key informants identified seven major threats to forage/fodder species and ranked these threats by degree of severity (Table 3). Overgrazing/over browsing, followed by deforestation scored 22% and 20%, respectively. Overgrazing/over browsing was one of the most serious problems in the ANP at the Saboer plain, Sogido, Geda, Sabure and Filwuha study sites due to large numbers of livestock, prolonged drought and dry season, and shortage of pasture. Many livestock were illegally grazed especially on Ilala Sala grassland, whereas Hamareti, Kereyu Lodge and Dunkuku study sites were not free from livestock. Such overgrazing and trampling by livestock can result in environmental degradation (Cotton 1996).

The threat of overgrazing was followed by deforestation for various purposes (e.g., firewood and charcoal production, building and construction, household furniture and farm tools, fencing materials and others), human settlement and agricultural expansion and forest fire. This confirms the results reported by Feyera and Demel (2003), that overgrazing by livestock, harvesting of plant resources and forest fire were the most significant anthropogenic threats. For these reasons useful plants such as *Acacia prasinata* and *A. negrii* are identified as threatened and near threatened endemics, respectively in and around ANP as listed by Vivero et al. (2005).

The pastoralists commented that encroachment on pastures by shrubs and trees (due to overgrazing/over browsing) is a major threat to grazing lands, sustainable land use and the conservation of biodiversity. Shrub and tree encroachment causes a gradual diminishing and disappearance of high-quality forage grasses such as *Chrysopogon plumulosus* (Jacobs and Schloeder 1993; Almaz and Masresha 1999). This species was replaced by en-

croachers such as *Acacia mellifera*, *Acacia oerfota*, *Acacia nilotica* and *Acacia senegal*, and this led to the decline of forage species as reported by Jacobs and Schloeder (1993). Gemedo (2004) reported that *Acacia mellifera*, *Acacia oerfota* and *Acacia senegal* are the most dominating encroachers of *Acacia* species

**Table 3:** Priority ranking of seven major human induced and natural impacts (threats) as perceived by key informants in the study area

Major threats in the study area	Key informants										Total scores	Percentage	Rank
	R <sub>1</sub>	R <sub>2</sub>	R <sub>3</sub>	R <sub>4</sub>	R <sub>5</sub>	R <sub>6</sub>	R <sub>7</sub>	R <sub>8</sub>	R <sub>9</sub>	R <sub>10</sub>			
Deforestation	7	7	5	5	7	4	5	3	6	5	54	19.9	2 <sup>nd</sup>
Forest fire	3	4	5	7	2	1	4	6	1	1	34	12.5	4 <sup>th</sup>
Human settlement and agricultural expansion	4	3	2	3	4	6	6	2	4	7	41	15.1	3 <sup>rd</sup>
Invasive alien plant species	1	2	2	1	1	5	2	4	1	4	23	8.5	7 <sup>th</sup>
Overgrazing/over browsing	7	5	7	5	7	7	6	7	5	3	59	21.7	1 <sup>st</sup>
Prolonged drought and dry season	1	2	3	3	2	3	3	4	7	1	29	10.7	6 <sup>th</sup>
Urbanization/modernization	4	6	4	2	5	2	1	1	3	4	32	11.8	5 <sup>th</sup>
Total scores	27	29	28	26	28	28	27	27	27	25	272	100	

Conservation and management of forage/fodder species and associated indigenous knowledge in the study area

The pastoralists employed indigenous management strategies to sustainably utilize and conserve the rangeland resources. These included the MEDA (Af) and GEDA (Or) systems, the highest decision-making indigenous social institutions in the Afar and the Oromo Nations, and both contributing to proper management of resources. The traditional regulation and management of plant resources has been the responsibility of these social institutions. Cutting of valuable shrubs and trees particularly for charcoal making as well as killing of wildlife is strictly prohibited without special permission granted by the clan chiefs. A similar system is used in the Kimphee Nature Reserve through the Oromo SHANACHA collective indigenous resource management system to manage and conserve forest resources (Feyera and Demel 2003). Other indigenous rangeland and herd management strategies practiced by pastoralists include herd mobility, herd diversification and herd splitting. These indigenous strategies allow the pastoralists to manipulate scarce resources, and hence to cope with arid and semi-arid environments in the study area. Similarly, shrub and tree fodders for livestock feed during dry seasons and drought are lopped, or leaves, seeds and pods are shaken down using sticks instead of cutting and felling the plants. Pastoralists often move from place to place during dry seasons in search of available resources (pasture and water) and using temporary huts rather than constructing new housing wherever they travel. As a result, they are more systematic and efficient in the use of plant materials for house construction. This is a good practice from the conservation point of view.

## Conclusion and recommendations

The Afar and the Oromo Nations mainly depend on forage/fodder species for their livestock feed. Their pastures are characterized by high diversity of forage/fodder species even

in the Borana rangeland. As a result, lower-quality forage species and unpalatable grass species like *Pennisetum setaceum*, *Pennisetum menzianum*, *Cymbopogon pospischilii*, *Sporobolus pyramidalis* and *Sporobolus spicatus* dominate the area.

though human-induced and natural factors influence plant survival and distribution. Overgrazing and deforestation are the major threats to forage/fodder species within the Park. We recommend development of improved animal husbandry practices to minimize overgrazing, strengthening and encouraging indigenous social institutions, improving the supply of grazing lands and water sources, and mechanical removal of shrubs and trees that encroach onto grasslands.

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**Appendix 1:** List of forage/fodder plant species in the study area (ANP)

Scientific name	Family name	Habit	Part(s) foraged (consumed)	Foraging animals	Major use category
<i>Abutilon ramosum</i> Guill. & Perr.	Malvaceae	H	Leaves & fruits	CG	F, Mc
<i>Acacia brevispica</i> Harms	Fabaceae	S	Leaves	CG	F, Fu, Fo, Mc
<i>Acacia dolichocephala</i> Harms	Fabaceae	T	Leaves & fruits	CG	F, Fu, Mc, Mi
<i>Acacia mellifera</i> (Vahl) Benth.	Fabaceae	S	Leaves, twigs & pods	AA	F, Fu, M, Fo, Mc, Mi
<i>Acacia negrii</i> Pic. - Serm.	Fabaceae	S	Leaves & fruits	CG	F, Fu, Mc
<i>Acacia nilotica</i> (L.) Willd. ex Del.	Fabaceae	T	Leaves, fruits & twigs	CG	F, Fu, M, Fo, Mc, Mi
<i>Acacia oerfota</i> (Forssk.) Schweinf.	Fabaceae	S	Leaves, twigs & pods	CG	F, Fu, M, Fo, Mc, Mi
<i>Acacia prasinata</i> Hunde	Fabaceae	T	Leaves	AA	F, Fu, Mc
<i>Acacia robusta</i> Burch.	Fabaceae	T	Leaves & branches	CG	F, Fu, Mc
<i>Acacia senegal</i> (L.) Willd.	Fabaceae	S	Leaves, branches & pods	CG	F, Fu, M, Fo, Mc, Mi
<i>Acacia seyal</i> Del.	Fabaceae	T	Leaves	CG	F, Fu, Fo, Mc
<i>Acacia tortilis</i> (Forssk.) Hayne	Fabaceae	T	Fruits, branches & pods	AA	F, Fu, M, Fo, Mc, Mi
<i>Acanthospermum hispidum</i> DC. *	Asteraceae	H	Leaves	AA	Mi
<i>Aristida adscensionis</i> L. *	Poaceae	H	Above ground	CaG	F, Mc
<i>Avena sativa</i> L. **	Poaceae	H	Above ground	Ca	F
<i>Azadirachta indica</i> A. Juss.	Meliaceae	T	Leaves	G	F, Fu, M, Mi
<i>Balanites aegyptiaca</i> (L.) Del.	Balanitaceae	T	Leaves, branches & fruits	AA	F, Fu, M, Fo, Mc, Mi
<i>Barleria acanthoides</i> Vahl **	Acanthaceae	S	Leaves	CG	F, Fu
<i>Barleria quadrispina</i> Lindau	Acanthaceae	H	Leaves	C	F
<i>Berchemia discolor</i> (Klotzsch) Hemsl.	Rhamnaceae	T	Leaves & fruits	AA	F, Fu, Fo, Mc
<i>Blepharis edulis</i> (Forssk.) Pers.	Acanthaceae	H	Above ground	C	F, M
<i>Boscia salicifolia</i> Oliv.	Capparidaceae	S	Leaves	C	F, Fu, Fo, Mc
<i>Boswellia papyrifera</i> (Del.) Hochst.	Burseraceae	T	Leaves	CG	F, Fu, Fo, Mc
<i>Bothriochloa radicans</i> (Lehm.) A. Camus	Poaceae	H	Above ground	Ca	F
<i>Cadaba farinosa</i> Forssk.	Capparidaceae	S	Fruits, leaves & flowers	CG	F, Fu, M, Fo, Mc, Mi
<i>Cadaba rotundifolia</i> Forssk.	Capparidaceae	S	Leaves	C	F, Fu, Mi
<i>Capparis tomentosa</i> Lam.	Capparidaceae	S	Leaves	CG	F, Fu, M, Fo, Mc, Mi
<i>Cardiospermum halicacabum</i> L. *	Sapindaceae	C	Leaves	C	F
<i>Caucanthus auriculatus</i> (Radlk.) Niedenzu **	Malpighiaceae	C	Leaves	C	F, Fu
<i>Ceiba pentandra</i> (L.) Gaertn. *	Bombacaceae	T	Leaves & twigs	CG	F, Fu, Fo, Mc, Mi
<i>Celtis toka</i> (Forssk.) Hepper & Wood	Ulmaceae	T	Leaves	AA	F, Fu, Fo, Mc
<i>Cenchrus ciliaris</i> L.	Poaceae	H	Leaves	AA	F
<i>Chascanum laetum</i> Fenzl. ex Walp.*	Verbenaceae	H	Above ground	Ca	F
<i>Chrysopogon aucheri</i> (Boiss.) Stapf	Poaceae	H	Above ground	Ca	F, Mc
<i>Chrysopogon plumulosus</i> Hochst.	Poaceae	H	Above ground	Ca	F, Mc
<i>Cleome brachycarpa</i> Vahl ex DC.*	Capparidaceae	H	Leaves	CG	F, Fu
<i>Coelachyrum pojflorum</i> Chiov. *	Poaceae	H	Above ground	Ca	F
<i>Combretum molle</i> R. Br. ex G. Don	Combretaceae	T	Leaves	CaG	F, Fu, Mc, Mi
<i>Commelina stephaniniana</i> Chiov.	Commelinaceae	H	Above ground	AA	F
<i>Commiphora erythraea</i> (Ehrenb.) Engl.	Burseraceae	T	Leaves & branches	AA	F, Fu, Mc
<i>Commiphora habessinica</i> (Berg) Engl.	Burseraceae	S	Leaves & fruits	AA	F, Fu, Fo, Mc, Mi
<i>Cordia monoica</i> Roxb.	Boraginaceae	S	Leaves	CG	F, Fu, Fo, Mc
<i>Crepis ruppellii</i> Sch. Bip. *	Asteraceae	H	Leaves	C	F
<i>Crinum abyssinicum</i> Hochst. ex A. Rich. *	Amaryllidaceae	H	All parts	Ca	F
<i>Cucumis prophetarum</i> L. **	Cucurbitaceae	H	Leaves	AA	F, M, Mc, Mi
<i>Cymbopogon pospischili</i> (K. Schum.) C.E. Hubb.	Poaceae	H	Above ground	Ca	F
<i>Cyperus rigidifolius</i> Steud. *	Cyperaceae	H	Above ground	Ca	F, M
<i>Dalbergia lactea</i> Vatke **	Fabaceae	S	Leaves	CG	F, Fu, Mc
<i>Dalechampia parvifolia</i> Lam. **	Euphorbiaceae	C	Leaves & young stems	CaG	F
<i>Dichrostachys cinerea</i> (L.) Wight & Arn.	Fabaceae	S	Leaves & fruits	AA	F, Fu, Mc, Mi
<i>Dicoma tomentosa</i> Cass. *	Asteraceae	H	Leaves	AA	F, Fu
<i>Digitaria pennata</i> (Hochst.) T. Cooke*	Poaceae	H	Above ground	Ca	F

## Continued Appendix 1

Scientific name	Family name	Habit	Part(s) foraged (consumed)	Foraging animals	Major use category
<i>Dobera glabra</i> (Forssk.) Poir.	Salvadoraceae	T	Leaves	CG	F, Fu, Fo, Mc, Mi
<i>Ehretia cymosa</i> Thonn.	Boraginaceae	S	Leaves	AA	F, Fu, M, Fo, Mc
<i>Eriochloa fatmensis</i> (Hochst. & Steud.) W.D. Clayton*	Poaceae	H	Above ground	CaG	F
<i>Euclea racemosa</i> Murr. subsp. <i>schimperi</i> (A. DC.) White**	Ebenaceae	S	Leaves	G	F, Fu, Fo, Mc
<i>Euphorbia tirucalli</i> L.	Euphorbiaceae	T	Stem	C	F, Fu, M, Mi
<i>Fagonia schweinfurthii</i> (Hadidi) Hadidi **	Zygophyllaceae	H	Leaves	C	F, M
<i>Fimbristylis ferruginea</i> (L.) Vahl *	Cyperaceae	H	Leaves	Ca	F
<i>Flacourtie indica</i> (Burm.f.) Merr. **	Flacourtiaceae	S	Leaves	CG	F, Fu, Fo, Mc
<i>Forsskaolea viridis</i> Webb. **	Urticaceae	H	Leaves & young branches	C	F, Fu
<i>Grewia bicolor</i> Juss.	Tiliaceae	S	Leaves & fruits	AA	F, Fu, Fo, Mc
<i>Grewia ferruginea</i> Hochst. ex A. Rich.	Tiliaceae	S	Leaves & fruits	AA	F, Fu, Fo, Mc
<i>Grewia schweinfurthii</i> Burret	Tiliaceae	S	Leaves & fruits	AA	F, Fu, Fo, Mc
<i>Grewia tenax</i> (Forssk.) Fiori	Tiliaceae	S	Leaves & fruits	AA	F, Fu, Fo, Mc
<i>Grewia velutina</i> (Forssk.) Vahl	Tiliaceae	S	Leaves & fruits	AA	F, Fu, Fo, Mc
<i>Grewia villosa</i> Willd.	Tiliaceae	S	Leaves & fruits	AA	F, Fu, M, Fo, Mc, Mi
<i>Heliotropium longiflorum</i> (A. DC.) Jaub. & Spach	Boraginaceae	C	Leaves	C	F
<i>Heliotropium zeylanicum</i> (Burm. f.) Lam	Boraginaceae	H	Leaves	CG	F
<i>Heliotropium undulatifolium</i> Turrill.	Boraginaceae	H	Leaves	C	F
<i>Hibiscus micranthus</i> L. f. *	Malvaceae	H	Leaves	C	F, Fu, Fo, Mc
<i>Hippocratea africana</i> (Willd.) Loes.	Celastraceae	C	Leaves	CaG	F, Fu, Mc
<i>Hyparrhenia anamesa</i> W. D. Clayton	Poaceae	H	Above ground	Ca	F
<i>Hyparrhenia diplandra</i> (Hack.) Stapf *	Poaceae	H	Above ground	Ca	F
<i>Hyparrhenia hirta</i> (L.) Stapf	Poaceae	H	Above ground	Ca	F, Mc
<i>Hyparrhenia rufa</i> (Nees) Stapf	Poaceae	H	Above ground	Ca	F, Mc
<i>Hyphaene thebaica</i> (L.) Mart. *	Arecaceae	T	Young leaves	Ca	F, Fu, Fo, Mc
<i>Justicia anagalloides</i> (Nees) T. Anders. **	Acanthaceae	H	Leaves	AA	F
<i>Kleinia odora</i> (Forssk.) DC. **	Asteraceae	S	Stem & leaves	CG	F, Fu, Mc, Mi
<i>Lantana camara</i> L.	Verbenaceae	S	Leaves	CG	F, Fu, Fo, Mc, Mi
<i>Maerua angolensis</i> DC.	Capparidaceae	S	Leaves & fruits	CG	F, Fu, Fo, Mc
<i>Manilkara butugi</i> Chiov.	Sapotaceae	T	Leaves	Ca	F, Fu, Fo, Mc, Mi
<i>Melhania ovata</i> (Cav.) Spreng. *	Sterculiaceae	S	Leaves	CG	F
<i>Morus mesozygia</i> Stapf	Moraceae	S	Leaves & fruits	CG	F, Fu, Mc
<i>Nanorrhinum hastatum</i> (R.Br. ex Benth.) Ghebr. **	Scrophulariaceae	H	Leaves	C	F
<i>Ocimum forskolei</i> Benth.	Lamiaceae	H	Leaves & fruits	CG	F, Mc, Mi
<i>Olea europaea</i> L. subsp. <i>cuspidata</i> (Wall.ex G.Don) Cif.	Oleaceae	T	Leaves & twigs	AA	F, Fu, M, Mc, Mi
<i>Panicum maximum</i> Jacq.	Poaceae	H	Above ground	AA	F, Mi
<i>Parkinsonia aculeata</i> L.	Fabaceae	S	Young branches & pods	C	F, Fu, Fo, Mc
<i>Pennisetum menzianum</i> Leeke	Poaceae	H	Above ground	Ca	F, Mc
<i>Pennisetum setaceum</i> (Forssk.) Chiov.	Poaceae	H	Above ground	Ca	F, Mc
<i>Peristrophe paniculata</i> (Forssk.) Brummitt *	Acanthaceae	H	Leaves	CG	F
<i>Premna resinosa</i> (Hochst.) Schauer	Lamiaceae	S	Leaves	CG	F, Fu, Fo, Mi
<i>Prosopis juliflora</i> (Sw.) DC.	Fabaceae	S	Leaves, branches & pods	CG	F, Fu, M, Fo, Mc, Mi
<i>Pupalia lappacea</i> (L.) A. Juss.	Amaranthaceae	H	Leaves	CG	F, M, Mc
<i>Rhus vulgaris</i> Meikle **	Anacardiaceae	S	Leaves & fruits	CG	F, Fu, M, Fo, Mc
<i>Salvadora persica</i> L.	Salvadoraceae	S	Leaves & fruits	CG	F, Fu, M, Fo, Mc
<i>Seddera arabica</i> (Forssk.) Choisy **	Convolvulaceae	H	Leaves	CaG	F
<i>Seddera bagshawei</i> Rendle	Convolvulaceae	H	Leaves	CaG	F, M
<i>Senna italica</i> Mill.	Fabaceae	H	Leaves & fruits	CG	F, M
<i>Sesbania sesban</i> (L.) Merr.	Fabaceae	S	Leaves	CaG	F, Fu, Mc
<i>Sida schimperiana</i> Hochst. ex A. Rich.	Malvaceae	S	Leaves	CaG	F, Fu, M, Mc, Mi
<i>Solanum coagulans</i> Forsk.	Solanaceae	H	Leaves & fruits	CG	F, Fu
<i>Solanum hastifolium</i> Hochst. ex Dunal	Solanaceae	S	Leaves	CaG	F, Fu

## Continued Appendix 1

Scientific name	Family name	Habit	Part (s) foraged (consumed)	Foraging animals	Major use category
<i>Solanum incanum</i> L.	Solanaceae	S	Leaves	CaG	F, Fu, Mc, Mi
<i>Solanum nigrum</i> L.	Solanaceae	H	Leaves & fruits	CaG	F, Fo
<i>Sorghum arundinaceum</i> (Desv.) Stapf	Poaceae	H	Above ground	Ca	F
<i>Sorghum purpureo-sericeum</i> (Hochst. ex A. Rich.) Aschers. & Schweinf.	Poaceae	H	Above ground	Ca	F
<i>Sporobolus cosimilis</i> Fresen.	Poaceae	H	Above ground	Ca	F, Mc
<i>Sporobolus ioclados</i> (Trin.) Nees *	Poaceae	H	Above ground	Ca	F
<i>Sporobolus pyramidalis</i> P. Beauv.	Poaceae	H	Above ground	Ca	F
<i>Sporobolus spicatus</i> (Vahl) Kunth	Poaceae	H	Above ground	Ca	F
<i>Sterculia africana</i> (Lour.) Fiori	Sterculiaceae	T	Leaves	CG	F, Fu, Fo, Mc, Mi
<i>Tamarindus indica</i> L.	Fabaceae	T	Leaves & fruits	AA	F, Fu, M, Fo, Mc, Mi
<i>Tamarix nilotica</i> (Ehrenb.) Bunge *	Tamaricaceae	S	Leafy branches	CG	F, Fu
<i>Terminalia brownii</i> Fresen.	Combretaceae	T	Leaves	CaG	F, Fu, M, Mc, Mi
<i>Tetrapogon cenchriflorus</i> (A. Rich.) Clayton	Poaceae	H	Above ground	Ca	F
<i>Tetrapogon tenellus</i> (Roxb.) Chiov.	Poaceae	H	Above ground	Ca	F
<i>Tragia mixta</i> M. Gilbert	Euphorbiaceae	C	Leaves	CG	F, M
<i>Typha</i> spp. *	Typhaceae	H	Leaves	Ca	F, Mc
<i>Vernonia cinerascens</i> Sch. Bip.	Asteraceae	S	Leaves & young shoots	AA	F, Fu, Mc
<i>Withania somnifera</i> (L.) Dunal	Solanaceae	H	Leaves	CG	F, M, Mc, Mi
<i>Ximenia americana</i> L.	Olaraceae	T	Leaves & fruits	CG	F, Fu, Fo, Mc
<i>Ziziphus mucronata</i> Willd.	Rhamnaceae	T	Leaves & fruits	AA	F, Fu, M, Fo, Mc, Mi
<i>Ziziphus spina-christi</i> (L.) Desf.	Rhamnaceae	T	Leaves & fruits	AA	F, Fu, M, Fo, Mc, Mi

**Major use category:** F = Forage/fodder; Fu = Fuel wood; M = Medicine; Fo = Food; Mc = Material culture; Mi = Miscellaneous uses.

**Foraging animals:** C = Camels; Ca = Cattle; G = Goats; AA = All animals (Camel, cattle, goat and sheep); CG = Camels & goats; CaG = Cattle & goats.

**Habit:** C=Climber; H=Herb; S=Shrub; T=Tree; \*Forage/fodder plant species reported by the Afar Nation; \*\*Forage/fodder plant species reported by the Oromo Nation; Plant species without asterisks are reported by both Nations